HAND TOOLS

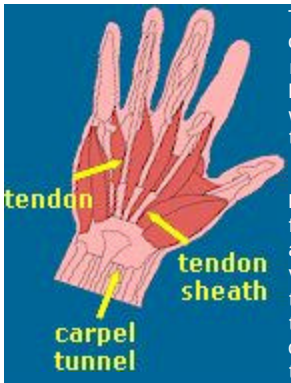
courtesy of: Ergonomics4schools

What are hand tools?

How many hand tools do you think you have used today? None? You may not have used what you would normally think of as a hand tool, such as a hammer, screwd river, or spanner, but what about a toothbrush, a spoon, a pen, scissors... They are all examples of 'tools' that you use to concentrate force and help you to carry out a variety of tasks. Powered hand tools, such as drills and circular saws, can deliver a great deal of force and speed, which can make tasks easier and quicker to do, but carry the risk of more severe injuries if an accident occurs. Good ergonomic design can reduce the potential for accidents or injury.

Anatomy of the hand and arm

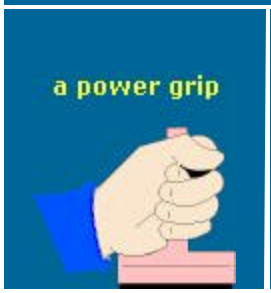
It is useful to have some anatomical knowledge of the arms and hands in order to know whether a hand tool is well designed and to know why certain hand and wrist positions can be harmful.



There are 27 bones in each hand and wrist. Ligaments connect one bone to another, and tendons connect the muscles to the bones. Ligaments and tendons stay the same length but muscles shorten when they contract. Therefore, when a muscle contracts, it pulls on the tendon which moves the bone to which it is attached.

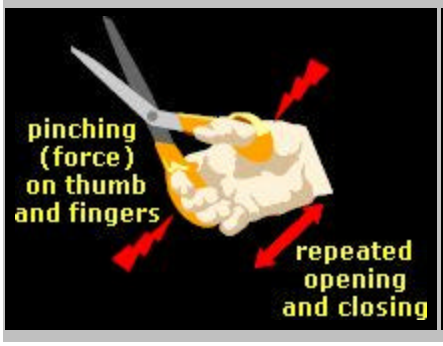
Most of the muscles that operate the hand are in the forearm. The tendons run from the muscles in your forearm and through the wrist to the bones in your hand. Blood vessels and nerves also pass through this narrow passage, the carpel tunnel, on the inside of your wrist. Parts of the tendons are enclosed in sheaths, which are slippery coverings that protect and lubricate the tendons and allow them to slide backwards and forwards smoothly. Sometimes hand tools need you to grip the handle and turn your hands so that they are bent at the wrist, (the same action of the hands and wrists used when wringing out wet clothes). An example is the screwdriver. When this occurs repeatedly, or with a lot of force applied, the tendons, nerves and blood vessels can get squashed at the wrist. These excessive movements can inflame the tendons or sheaths and cause pain or swelling.

The palm of the hand contains a network of nerves and blood vessels and should not be subjected to excessive pressure. This could cause damage to these 'soft tissues' (any part of your body except your bones, teeth and nails) resulting in bruising, or numbness or tingling in the fingers. Paint scrapers and pliers usually do press into the center of your hand.

Try this!	Try clenching your fist and see and feel the muscles in your forearm change shape. Look at the inside of your wrist. When you bend your wrist backwards and forwards you can see veins (blue lines), and you can see and feel tendons (firm, straight structures running from your hand up your forearm). When you straighten or stretch your fingers, you can see the tendons on the back of your hand, running over your knuckles. When you bend your wrist, or press on the inside of your wrist, you compress the blood vessels, nerves and tendons in the carpel tunnel. You might feel tingling in your fingers and the movement in your fingers may be restricted or slightly uncomfortable, too. If you let your hand relax on your lap, it will naturally fall into a 'position of rest', where all the tendons and muscles are most comfortable and least stressed. Tools and handles should be designed to make sure that we can keep our hands and wrists in comfortable positions. Hands are stronger and less vulnerable to injury when the wrists are kept straight.
	There are two main types of grip that you normally use:
	  A **power** grip - used to hold a hammer, for example, which uses relatively strong muscles in the forearm. Your whole hand wraps around the handle. A **precision** grip (or a pinch grip) - used to hold a nail or a pencil, which uses smaller and weaker finger muscles. The item is held between your thumb and index finger.

Using badly designed hand tools

We already know two things that make our hands and wrists uncomfortable - repeated muscle use, which can lead to painful tendons, and excessive bending, which causes discomfort and restricted movement. Bending of the wrist can be backwards (*extension*), forwards (*flexion*) or sideways (*deviation*). The third factor that can cause discomfort and may lead to injury is the amount of effort or force needed to grip a handle or use a tool.

SCISSORS	SCRAPER	SCREWDRIVER
		

A combination of high forces, repetitive movements, and awkward or extreme joint positions increases the likelihood of injuries to the arms and hands, which are known as upper limb disorders. The symptoms may be felt quickly or they may take a long time to develop – weeks, months or sometimes years.

Some hand tools have been designed to make them fairly acceptable to lots of people. But designing for the 'average' person actually means that a large number of people find things difficult to use. Also, most tools are designed for use by men and they are rarely suitable for the smaller hands of women.

Guidelines for hand tool design

TOOL WEIGHT

Tools that are too heavy will make you tired very quickly and will be difficult to control. There is no single weight limit that can be recommended for hand tools. An acceptable weight for a sledgehammer would be completely unsuitable for a pair of pliers! It should be possible to carry a tool in one hand without strain. Otherwise, it should have two handles to allow you to hold it in both hands – one hand for support and one for control.

Sometimes the distribution of the weight within the hand tool makes it more difficult and tiring to use. Power drills, for example sometimes have a center of gravity to the left or right of the handgrip. This creates a turning force that you have to steady the tool against, in addition to holding, positio ning and pushing the drill into the work piece. A second handle on the side allows extra control. It should be able to be located on either side to allow both right and left-handed people to use it easily.

For large, heavy hand tools such as nutrunners, which are used to undo bolts on vehicle wheels, for example, the tool may be suspended from the ceiling on a spring-loaded cable. Doing this means that you only need to position the hand tool in the right place, while the cable takes the weight.

TOOL HANDLES

Diameter

The best size and shape of the handle will depend on the nature of the task. You use a power grip for hand tools that are used with force, such as a hammer or wrench. Handles for these tools need to have a greater diameter than those that are held with a precision grip, such as a small paintbrush, or scalpel. The recommended diameter for a power grip is 40-45mm. The recommended diameter for a precision grip is 8-16mm. Certain tools require the use of both grips. The screwdriver usually requires a precision grip as a loose screw is tightened, then a power grip to drive it in. In this case the ideal handle diameter is a compromise between 25 and 40mm.

Ridges

Some screwdrivers have 'fluted' handles (deep ridges along the length) and others are smooth. A smooth handle is best as there is a large surface area for gripping. If the screwdriver is small, however, a hexagonal cross-section or slight fluting can help prevent the handle from slipping in your hand. The general rule is that if a handle is to be grasped and squeezed, it should spread the pressure over as large an area of your palm and fingers as possible.

Length
The length of a handle should be at least 100mm, so that the end of the handle does not finish in the palm of your hand. Ideally, the handle should be up to 130mm, so that the palm of even the largest hand is cleared and there is less risk of the handle doing damage by compression of the soft palm tissues. If a hand tool is small and used for very light work, sometimes it is acceptable for the end of the handle to lie in the palm.

Indentations
Finger ridges or indentations along the handle are not recommended. If you have particularly small or large hands, you may find that the grip is uncomfortable because your fingers are spread too wide to allow a good grip, or the ridges in the handle lie uncomfortably among your fingers. Finger indentations also encourage your hand to stay in one position and this might not be suitable for all tasks.

Shape
Sometimes hand tools like pliers have 'bent' handles, to try and keep the hand and wrist in a straight (neutral) position. But this only works if the tool is used in the position that it was designed for, all the time. The best design will depend on the task for which it will be used.

Material
The material should be a poor conductor of heat and electricity, and should be non-porous so that it will not soak up and retain oil or other liquids. Materials should be strong enough not to chip or crack and injure your hand.

Guarding
A guard at the front of the grip prevents your hand from slipping forward – important in tools such as knives and soldering irons.

Texture
The surface texture of the handgrip should reflect the type of gripping involved. A broom handle, for example, does not need a textured surface, but it may be useful on a handgrip where high forces must be applied, as it would make it slip resistant and gives good feedback to your hands. You do not need to grip the handle as hard if the surface is textured as it increases friction.

Triggers
Your thumb is the most suitable digit for strong, repeated activation of push buttons or triggers located on the handle or main body of a hand tool. This is because your thumb is operated by strong short muscles located within your palm and does not tire quickly. Your index finger has an additional muscle that is best suited for actions involving extension of your finger - repetitive pointing. It is not so good for repetitive bending because the muscle that makes it bend works against the muscle that makes it extend. This means that the thumb is best suited for triggers despite the common practice of using the index finger. However, the weight and shape of the tool must allow your thumb to be moved to operate a trigger without the tool slipping from your grasp.

Gloves
If you wear gloves, your hand effectively becomes bigger, so the handle size should be correspondingly bigger, by about

10mm.

WORKSTATIONS

Poor working postures are still possible even when using well-designed hand tools because the workstation affects the way they are used. If a job requires precise and intricate work but the workstation is too low, for example, you might have to bend forward and work in an uncomfortable posture. There are two main issues in body posture - what your eyes need to see and what your hand needs to grip. If the job involves applying force, the work piece should be just below elbow height. If it is more precise, the work piece may need to be nearer to your eyes. If possible, it is a good idea to secure the work piece on the workstation, so that one hand is not used just to support the object. This reduces the overall effort.